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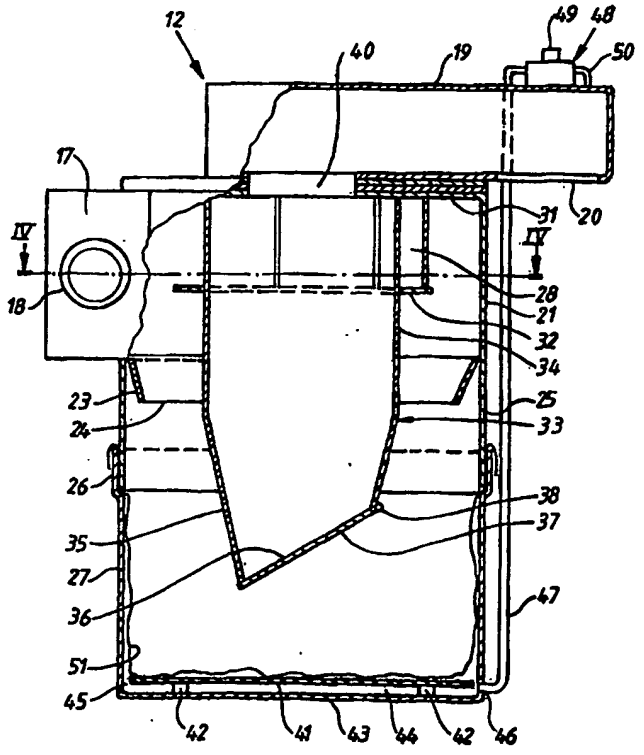
(54) Title: CYCLONE SEPARATOR FOR A VACUUM CLEANER

(57) Abstract

A cyclone separator for a vacuum cleaner including an inlet part (17), an outlet part (19), and first and second cyclones which are connected in series to each other and disposed between the inlet and outlet parts. The first and second cyclones are each provided with an opening (24, 36) facing a common collecting container (27). The collecting chamber receives particles separated by the cyclones and is placed below the two cyclones. The opening (36) of the second cyclone is provided with a valve (37) which automatically closes the second cyclone opening (36) when the cyclone separator is used.



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CYCLONE SEPARATOR FOR A VACUUM CLEANER

The present invention relates to a cyclone separator for a vacuum cleaner, the separator comprising an inlet part, an outlet part, and first and second cyclones which are connected in series and disposed between the inlet and outlet parts.

Vacuum cleaners comprising serially-connected cyclones for separating particles are previously known. See, for example, EP 489565 and US 5090976. In order to achieve a compact structure, one of the cyclones is placed within the other cyclone. The two cyclones are, with the exception of their common inlets and outlets, separated from each other with regard to flow conditions and, as such, each cyclone has its own collecting container which separated particles fall down into under the influence of gravity. The two collecting containers are separated by a removable intermediate wall.

Unfortunately, this arrangement is complicated and emptying the container, or a bag which may be received in the container, is unhygienic since the intermediate wall has to be removed manually before the particles, which are collected in the container or in the bag, can be removed. Accordingly, it is common for dust to whirl up and spread to the surrounding environment during emptying of the container or bag.

It is also previously known to use a special bag, which is inserted in the container, for vacuum cleaners of the above-mentioned type, (see US 5145499). For these special bags, the intermediate wall is integrated into the bag. Unfortunately, such special bags are expensive.

Accordingly, there exists a need in the art for a cyclone separator having a structure which facilitates emptying of separated particles therefrom. There also exists a need for a cyclone separator incorporating an inexpensive collecting bag which can be hygienically emptied.

The present invention is directed toward a more simple

arrangement for a vacuum cleaner having a two stage cyclone separator wherein particles separated by the two cyclones are collected in a common container. Thus, the container has no separating wall and is preferably equipped with a conventional plastic bag for collection of dust particles.

In accordance with the present invention, a cyclone separator includes an inlet part, an outlet part, and first and second cyclones. The first and second cyclones are connected in series, and are disposed between the inlet part and the outlet part.

In further accordance with the present invention, the first cyclone concentrically surrounds the second cyclone, and air travels in a first direction in the first cyclone and in a second, opposite direction in the second cyclone. The change in air direction between the first and second cyclones helps to minimize the amount of particles communicated from the first cyclone to the second cyclone.

In further accordance with the present invention, the first and second cyclones each have an opening facing a common collecting container for particles separated by the cyclones. The collecting container is disposed beneath the cyclones. The opening of the second cyclone includes a valve which is operable to close the second cyclone opening when the cyclone separator is being used. Particles separated by the second cyclone are retained in the second cyclone by the valve until the vacuum cleaner is turned off.

In further accordance with the present invention, the valve comprises a flap member which is pivotally secured to an edge of the second cyclone opening. The flap member is pivotally moved to a closed position by pressure differentials when the vacuum cleaner is operated, and pivotally moves to an open position due to gravity when the vacuum cleaner is turned off.

These and further features of the present invention will be apparent with reference to the following description and drawings, wherein:

Fig. 1 is a schematic vertical view showing a vacuum cleaner provided with a cyclone separator according to the present invention;

Fig. 2 is a partially-broken vertical view through the cyclone separator according to the present invention;

Fig. 3 is a top plan view of the cyclone separator shown in Fig. 2;

Fig. 4 is a sectional view of the cyclone separator as seen along line IV-IV in Fig. 2.

With reference to Fig. 1, a vacuum cleaner including a vacuum cleaner housing 10 enclosing a vacuum source designed as a motor-fan unit 11 is illustrated. The inlet side of the fan is connected to a cyclone separator 12 arranged at a front part of the vacuum cleaner. The cyclone separator 12, via a hose 13, a tube handle 14, and a tube shaft 15, communicates with a nozzle 16.

The cyclone separator 12 has an inlet part 17, an outlet part 19, and first and second cyclones. The inlet part 17 includes a sleeve 18 to which the hose 13 is connected. The outlet part 19 defines an opening 20 which is connected to the inlet side of the fan. The first and second cyclones are connected in series between the inlet part 17 and outlet part 19.

The first cyclone comprises a first cyclone housing 21 having a circular cross section into which air flows tangentially from the inlet part 17 through a first inlet 22. The cyclone housing 21 supports an annular liner 23 shaped as a hollow, truncated, up-side-down cone defining a centrally arranged first opening 24. The cyclone housing 21 extends below the liner 23 thereby forming a circular flange part 25 which can be placed in a sleeve-shaped enlargement 26 of a cylinder shaped container 27. The liner 23 is disposed relatively between the first inlet 22 and the flange part 25, as illustrated.

The first cyclone is further provided with a first outlet 28 comprising several openings arranged at the periphery of a circle spaced a distance from and radially inside the cyclone housing

21. The openings forming the first outlet 28 continue into gradually narrowing channels 29, each channel having side walls formed by two adjacent plate-shaped elements 30 which are secured between an upper annular plate 31 and a lower annular plate 32. The upper plate 31 also forms a roof part of the first cyclone housing 21.

The upper plate 31 supports a second cyclone housing 33 for the second cyclone. The second cyclone housing 33 has an upper cylinder-shaped part 34 which is radially surrounded by the lower annular shaped plate 32. The cyclone housing 33 also has a lower-tube shaped part 35 which extends through the inlet opening 24 of the liner 23, as illustrated. Relatively beneath the liner 23, the tube-shaped part 35 has a gradually decreasing diameter and a second opening 36 facing the container 27. The second opening 36 is provided with a flap member 37 which is pivotally supported at the periphery of the second opening 36 by means of a hinge 38.

The outlet openings of the channels 29 form second inlet openings 39 which are directed tangentially with respect to the second cyclone housing 33. The channels 29 are directed such that the air flow direction in the second cyclone is reversed with respect to the air flow direction in the first cyclone, as illustrated in FIG. 4. The second cyclone also has a second outlet 40 which is a central circular opening in the upper plate 31. The second outlet 40, via the tube shaped outlet part 19, is connected to the opening 20.

The container 27 has a circular plate 41 which, by means of widely spaced-apart distance means 42, is fixed above a bottom wall 43 of the container to define a chamber 44 between the plate 41 and the bottom wall 43. The plate 41, which may be perforated, has a somewhat smaller diameter than the inner diameter of the container 27, thereby creating a circumferential gap or slot 45 between the container side wall and the periphery of the plate 41.

The chamber 44 and gap or slot 45 are, by means of a nipple

46 and a tube connection 47, connected to a valve 48 placed on the outlet part 19. The operating condition of the valve 48 is controlled by a control means 49. The valve 48 is also, via a tube connection 50, connected to the outlet part 19. Accordingly, when the valve 48 is in an open position, the chamber 44 and slot 45 are in fluid communication with the outlet part 19.

The container 27 receives a bag 51 made of a material which is air impermeable, such as plastic. The upper end of the bag 51 is clamped between the enlargement 26 of the container 27 and the flange part 25 of the first cyclone housing, and effectively seals the upper extent of the gap or slot 45.

The device operates in the following manner. When the vacuum cleaner is started an under-atmospheric pressure is created in the cyclone separator. Air turbulence causes the flap member 37 to initially pivotally oscillate. Thereafter, pressure differences between the first and second cyclones cause the flap member 37 to pivot to a closed position to seal the second opening 36. At the same time, dust laden air is drawn into the cyclone separator through the inlet part 17 and the inlet opening 22.

The dust-laden air flows via the tangentially directed opening 22 into the first cyclone housing 21 and creates a first vortex which surrounds the cylinder part 34 of the second cyclone housing 33. Due to centrifugal forces, particles in the first vortex are thrown radially outward and then fall downwardly, due to gravity, through the first opening 24 and into the bag 51 inserted in the container 27. At the same time, partially cleaned air from the more central area of the first vortex flows through the first outlet 28 and the channels 29 and into the second cyclone housing 33 through the second inlet openings 39.

Since the second inlet 39 is tangentially directed with respect to the second cyclone housing 33, the inflowing air in the second cyclone housing creates a second, inner vortex having a smaller diameter and rotating in an opposite direction with

respect to the first or outer vortex. Due to the inertia of the particles and the rapid change of direction of the air stream, most of the particles are unable to enter the second cyclone and instead remain with the first vortex in the first cyclone housing 21. In the second cyclone housing 33 additional particles are centrifugally separated. These additional separated particles fall downwardly and collect on the flap member 37.

Cleaned air at the center portion of the second vortex flows upwardly and out through the second outlet 40 and into the outlet part 19. From the outlet part 19, the cleaned air flows through the opening 20, and also through conventional, mechanical filters (not shown), if any, upstream of the motor-fan unit 11 before entering and being exhausted from the motor-fan unit 11 and the vacuum cleaner. When the vacuum cleaner is shut off there is a pressure equalization between the spaces on each side of the second cyclone housing 33. Accordingly, the flap member 37, because of its own weight and the weight of particles thereon, pivots downwardly toward a vertical position to permit the particles resting on the flap member 37 to fall down into the bag 51.

The cyclone separator is emptied by removing the container 27 from the flange part 25 of the cyclone housing 21 whereby the bag 51 with the collected particles can be removed from the container and thrown away. When inserting a new bag in the container 27, the open end of the bag is clamped between the flange part 25 and the enlargement 26 at the upper end of the container 27 after which the vacuum cleaner is started. Normally the valve 48 is then in an open position. This means that an under-atmospheric pressure is established in the chamber 44 and air which is trapped between the bag 51 and the container wall will be drawn out through the tube connection 47, 50 and draw the bag 51 against the container wall and the plate 41. In case a bag is not used in the container, the valve 48 is closed.

In order to prevent the valve 37 from being partially opened when there is a pressure drop in the cyclone separator (which

could cause particles collected on the valve to follow the air flow to the outlet part 19), for instance when the vacuum cleaner is shut off, the vacuum cleaner is preferably provided with means for sensing a pressure drop and activating a valve which cuts off the supply of air to the cyclone.

CLAIMS

1. A cyclone separator for a vacuum cleaner, said separator comprising an inlet part (17), an outlet part (19), and first and second cyclones which are connected in series to each other and disposed between the inlet part and the outlet part, **characterized in** that the first and second cyclones each include an opening (24,36) facing a common collecting container (27) for particles separated by the cyclones, said collecting container being disposed relatively below each of said cyclones, the opening (36) of the second cyclone being provided with a valve (37) which automatically closes the second cyclone opening (36) when the cyclone separator is used.

2. A cyclone separator according to claim 1, **characterized in** that the second cyclone is concentric with the first cyclone and placed within the first cyclone.

3. A cyclone separator according to claim 2, **characterized in** that the first cyclone has a tangentially directed first air inlet (22) and a first outlet (28), said first outlet communicating with the second cyclone via at least one tangentially directed second inlet (39), the second cyclone being provided with a second centrally arranged outlet (40) through which air escapes from the second cyclone to said outlet part (19).

4. A cyclone separator according to any of claims 1-3, **characterized in** that the valve (37) comprises a flap member which is pivotally secured to the second cyclone adjacent the second cyclone opening (36).

5. A cyclone separator according to claim 4, **characterized in** that the flap member (37) is adapted to move toward an open position by gravity.

6. A cyclone separator according to any of claims 2-5, **characterized in** that air rotates in a first direction in the first cyclone and rotates in a second, opposite direction in the second cyclone.

7. A cyclone separator according to any of the preceding claims, **characterized in** that it further comprises an air-impermeable bag disposed in said collecting chamber, said collecting container (27) being provided with an air distributing system, said air distributing system being operable to evacuate air from a space between said bag and said container.

8. A cyclone separator according to claim 7, **characterized in** that the air distributing system comprises a plate (41) spaced a distance from a bottom wall (43) of the container, and wherein a chamber (44) defined by said container bottom wall and said plate is connected to said outlet part by means of a tube conduit (47, 50).

9. A cyclone separator according to claim 8, **characterized in** that said tube conduit (47, 50) is connected to a valve (48), said valve being operable to regulate air flow through the tube conduit.

10. A cyclone separator according to any of the preceding claims 1, **characterized in** that it further comprises a pressure sensing means, said pressure sensing means being adapted to activate a valve which momentarily shuts off the air supply to the cyclone separator when a pressure drop of a predetermined magnitude is sensed in said cyclone separator.

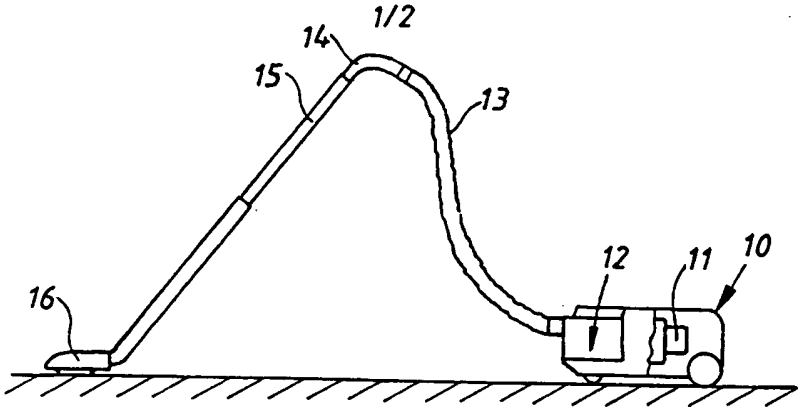
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FIG. 1

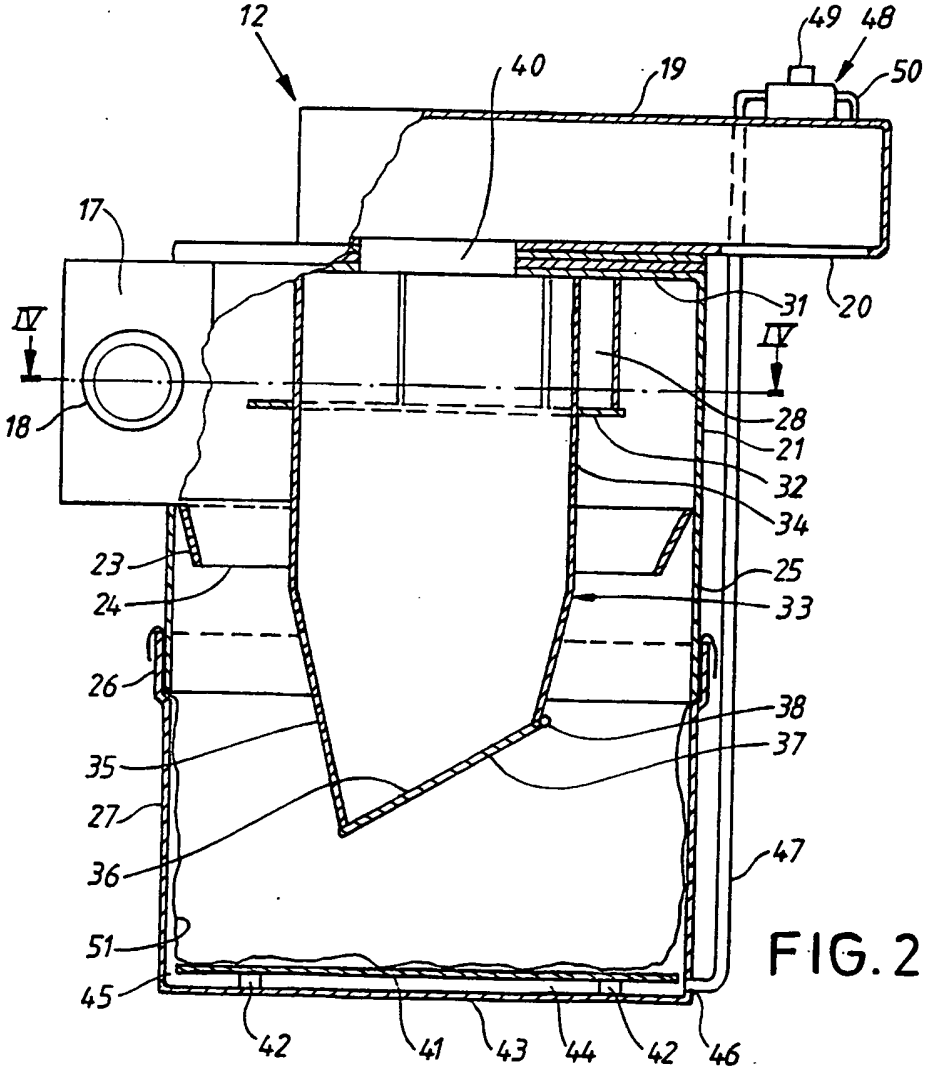
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FIG. 2

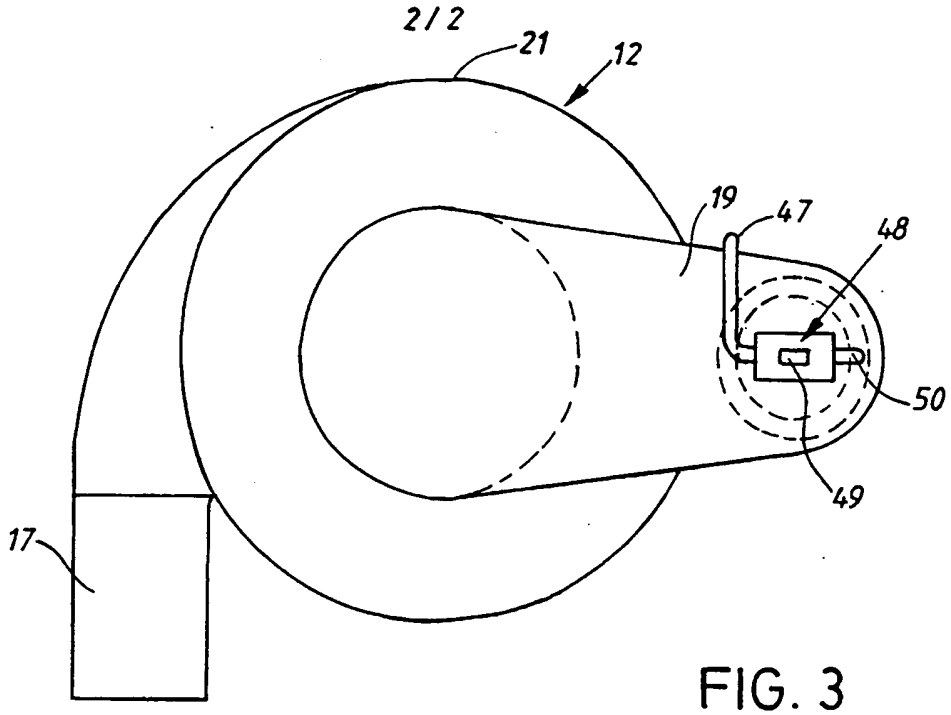

FIG. 3

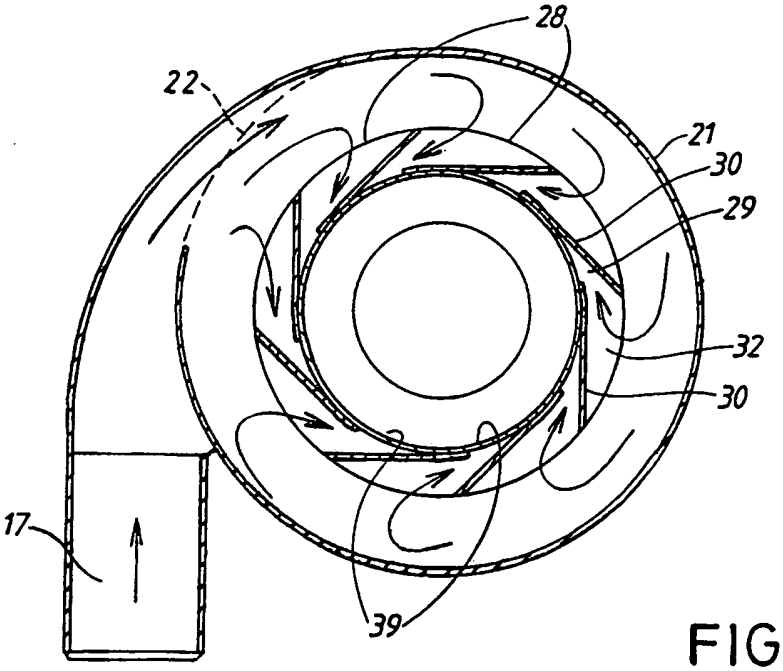

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/00240

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A47L 9/16 // B04C 5/185
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A47L, B04C, B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0489565 A1 (NOTETRY LIMITED), 10 June 1992 (10.06.92), figure 2, abstract ---	1
A	US 5090976 A (DYSON), 25 February 1992 (25.02.92), figures 1-3, abstract ---	1
A	US 5145499 A (DYSON), 8 Sept 1992 (08.09.92), figure 2, abstract --- --------	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/03/98

International application No.
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